INTRODUCTION

Many Endo Urological procedures require the use of an irrigation fluid to dilate the operating field and to wash away debris and blood.

A potential complication of such irrigation is systemic absorption of the fluid and serum electrolytes changes; particularly serum sodium to the extent that overt symptoms are produced. The consequences depend on the rate, volume and nature of the fluid absorbed. Other adverse effects due to fluid absorption soon became apparent. They arise in both the cardiovascular and nervous systems, and in the late 1950s, became known as the 'transurethral resection(TUR) syndrome'. Since then, several hundred life threatening and even fatal events have been reported(36,39,51). Severe events are associated with serum sodium level < 115 Meq/l.

Complications in TURP patients are due to acute water intoxication and concomitant " Dilutional Hyponatremia ," if severe enough cause vascular collapse (1,2).

This interesting observations induced me to do Prospective study about , clinical relevance of " Dilutional Hyponatremia," in endoscopy patients.

.

AIM

The aim of this prospective study is to analyse serum sodium changes and its clinical relevance in Benign Prostatic Hyperplasia Patients who underwent Transurethral Resection of Prostate in our institution from February 2005 to January 2007.

PHYSIOLOGY

Sodium dynamics in normal person

Sodium is the major cat-ion of extra cellular fluid. Because it represents approximately 90% of the inorganic cat-ion charge per liter of plasma. Na is responsible for almost one half the osmotic strength of plasma. It therefore plays a central role in maintaining the normal distribution of water and osmotic pressure in the extra cellular fluid component(15).

The normal daily diet contains 8 to 15g of NaCl, which is nearly completely absorbed from the gastrointestinal tract. The body requires only 1 to 2 mmol/day, and excess excreted by kidneys, which are ultimate regulators of the amount of sodium (and thus water) in the body.

Sodium is initially freely filtered by glomeruli. Then 70 to 80% of filtered sodium load is actively reabsorbed in the proximal tubules with chloride and water passively following in an iso-osmotic and electrically neutral manner. Another 20 to 25% is reabsorbed in the loop of Henle along with chloride and water . In the distal tubules, interaction of adrenocortical hormone aldosterone with the coupled sodium, potassium and sodium, proton exchange systems directly results in reabsorption of sodium and indirectly of chloride, from the remaining 5 to 10% of filtered load. It is the regulation of this latter fraction of filtered sodium that determines the amount of sodium excreted in the urine.

Reference intervals

The interval for serum sodium is 135 to 145 Meq/L from infancy throughout life(12,13). Urinary sodium excretion varies with dietary intake, but people on an average diet containing 8 to 15 g/d , and interval of 40 to 220 mmol is typical (12). There is large diurnal variation in

sodium excretion, with the rate of sodium excretion during the night being only 20% of the peak rate during the day.

Fluid dynamics in normal person

Total body water in adult male is 60% of his body weight that is 42 liters. Approximately two thirds of total body water; 40% of his weight; 28 liters of water is distributed in to the intracellular fluid (ICF) compartment and one third of total body water; 20% of his weight; 14 liters of water is distributed into the extra cellular fluid (ECF) compartment(3).

The extra cellular fluid compartment may be further subdivided into the interstitial fluid compartment; 15% of his body weight; 10.5 liters of water and intravascular compartment; 5% of his body weight; 3.5 liters of water(3).

Movement of water between compartments

When a patient takes in water, either by drinking or in the form of a 5% glucose infusion, the glucose in which is soon metabolized. It will rapidly distribute throughout the extracellular fluid compartment with a resultant fall in extracellular fluid compartment osmolality. Since osmolality must be same inside and outside cells, water will move from extracellular compartment to intracellular compartment until the osmolalities are the same. Thus 1 liter of water or 5% glucose given to a patient will distribute itself throughout the body water. In spite of being infused into the intravascular compartment , it will be distributed throughout the body water space(4).

PATHO PHYSIOLOGY

Water intoxication was first described by Wier et al. in 1922(38)

Hyponatremia is defined as a decreased plasma sodium concentration < 136 Meq/L. hyponatremia manifests itself clinically as generalized weakness and mental confusion at values < 120 Meq/L, bulbar or pseudobulbar palsy at <110 Meq/l/L and severe mental impairment between 90 and 105 Meq//L (5,13).

The central nerves system symptoms are primarily due to intracellular shifting of water to maintain osmotic balance resulting in swelling of central nerves system cells(5).

The rapidity of the development of hyponatremia influences the level of sodium at which these symptoms develop; thus clinically apparent symptoms may manifest at slightly higher Na+ levels; < 125 Meq/L(5).

Types of Hyponatremia

1. **Hyperosmotic Hyponatremia**
2. **Isosmotic Hyponatremia**

3. hypo-osmotic Hyponatremia

Type 1

When hyponatremia occurs in the presence of an increased plasma osmolality, this can be due to an increased amount of other solutes in the extracellular fluid.

Eg: hyperglycemia. Serum Na+ has inverse relationship with serum glucose level(6).

Type 2

Normal osmolality with decreased serum Na+ levels seen in hyper lipidemic and paraproteinemic patients (6)

Type 3

Typically when plasma Na+ concentration is low, the calculated or measured osmolality will also be low. This type of hyponatremia can be due to

either excess loss of Na+ - “ Depletional Hyponatremia,” or increased extracellular fluid volume – ‘ Dilutional Hyponatremia,”(6)

Dilutional Hyponatremia & Trans Urethral Resection Syndrome

Irrigating fluid is most frequently absorbed directly into the vascular system when a vein has been severed by electro surgery. The driving force is the fluid pressure, which needs to exceed the venous pressure. The period of time that the fluid pressure exceeds 15 mm Hg, the absorbed volume increases significantly (7,9). Major fluid absorption rarely stops once initiated and often coincides with a decrease in arterial pressure(8).

Significant amounts of fluid may be absorbed during a TURP, especially if venous sinuses are opened early or when the operation is prolonged. On average during a TURP, approximately 20 mL of fluid per minute is absorbed, or approximately 1000-1200 mL in the first hour of

resecting time. One third of this fluid is absorbed directly into the venous system. This may lead to dilutional hyponatremia .

The risk is increased in patients with prostates larger than 45 grams, when the resection time is prolonged beyond 90 minutes, and when the patient has relative hyponatremia preoperatively. Therefore, a TURP is recommended only when the operating surgeon is reasonably convinced of being able to finish the procedure in no more than 90 minutes.

The risk is reduced by keeping the inflow irrigating fluid pressure as low as possible. A study by Madsen and Naber(9) found that fluid absorption was directly related to irrigation fluid pressure. Raising the height of the fluid from 60 cm to 70 cm doubled the irrigation fluid pressure. They also found that an irrigation rate of 300 mL/min was necessary to maintain good visualization and that this rate cannot be adequately maintained if the fluid height is less than 60 cm.

Continuous-flow systems tend to keep the intravesical pressure low and help minimize fluid absorption. If not using a continuous-flow methodology, to minimize fluid absorption, the bladder should be emptied routinely before maximum bladder filling has occurred and visualization is lost.

Fluid absorption is an unpredictable complication of endoscopic surgery. Absorption of small amounts of fluid (1–2 liter) occurs in 5–10% of patients undergoing transurethral prostatic resection and results in an easily overlooked mild transurethral resection (TUR) syndrome(81).

Large-scale fluid absorption is rare but leads to symptoms severe enough to require intensive care. Pathophysiological mechanisms consist of , the volume effect of the irrigant water, dilutional hyponatraemia and brain oedema. Other Preventive measures, such as low-pressure irrigation, might reduce the extent of fluid absorption but does not eliminate this complication.

In patient with normal renal function, water diuresis may be limited temporarily by ADH secretion induced by various neural stimuli such as pain and narcotics(20).

In those patients who have transurethral resection reactions acute relative water intoxication develops and unless promptly treated, a critical dilutional hyponatremia may ensue which precipitates peripheral vascular collapse. Shock is known to decrease renal function(24).

Risk factors

Smoking is the only patient factor known to be associated with large-scale fluid absorption during TURP(22).

Smoking may also alter the vascular growth of the prostate, leading to additional potential blood loss and fluid absorption. Persons who smoke tend to have 22% higher

average serum levels of vascular endothelial growth factor compared with nonsmokers. This is presumably because of the lower average blood oxygen levels in smokers. In addition, the tobacco may directly affect prostatic tissue and/or vasculature, resulting in increased irrigation fluid absorption.

Fluid absorption increases with the extent of the resection as the exposure is prolonged. Visual indications of fluid absorption to the surgeon are usually lacking, although capsular perforation(23), which occurs in at least 10% of the TURPs, or apparent damage to a venous sinus increases the likelihood of its occurrence.

The normal response by the kidneys to hyponatremia is to excrete the extra free water. Various factors can interfere with this process, as follows:

- **Renal failure and a reduced glomerular filtration rate result in less renal free water excretion.**

- **Increased proximal renal tubular reabsorption from decreased extracellular volume or edema reduces free water delivery to the diluting segment of the kidney.**
- **Thiazide diuretics directly interfere with the renal diluting mechanism.**
- **Inappropriate antidiuretic hormone (ADH) syndrome inhibits renal free water excretion and causes hyponatremia. It can be caused by head injury, adrenal insufficiency, hypothyroidism, psychotropic medications, and urinary tract infections, among other etiologies.**

Incidence

Mild to moderately severe TUR syndrome occurs in between 1 and 8% of TURPs performed(10,11,14,25,26) Certain smaller patient series

have a higher incidence(27,28,29), while others do not report any cases.26 The use of a checklist to grade symptoms is recommended (Table 1).(30,31,32) In larger case series, the incidence of the TUR syndrome may be <1%.

The patient sometimes reports transient prickling and burning sensations in the face and neck, becomes restless and complains of headache. The most consistent signs are bradycardia and arterial hypertension 'Feeling bad' is slightly more common than perioperative nausea, which is reported by 5–10% of the patients. Chest pain occurs in 5% of the patients who absorb >1 liter, and is more likely if the blood loss is small(33).

The most common signs and symptoms are nausea and arterial hypertension followed by vomiting and low urinary output, all of which become more frequent as more irrigating fluid is absorbed. Arterial hypotension becomes less common when more irrigating fluid is being absorbed.

Depressed consciousness develops in 5% of the patients after absorption of >1 liter of fluid.

Diarrhea occurs in 20% of those who absorb >3 liter. Abdominal pain is reported by 10–20% of patients who absorb >1 liter of fluid. This symptom is strongly related to extravasation, which is also associated with a higher incidence of arterial hypotension and poor urinary output(34). Clinician should be aware of a mild TUR syndrome, which is easily overlooked. This presents with nausea and often a sudden increase in arterial pressure 30–45 min after the operation(30,31,32). Serum sodium is lowered 5–10 Meq/liter(14). Apparent confusion may occur in response to absorption of 1–2 liter, but is more consistent with larger absorption volumes (10,27) and might proceed to depressed consciousness (35) and coma(36).

The incidence of acute myocardial infarction during TURP is between 1 and 3%. Evidence of cardiac ischemia, using ECG, was found in 25% of TURP patients, mostly in those with known cardiovascular disease(37). A marginal increase in cardiac enzymes occurred in 7% of all TURP patients.

Severe TUR syndrome is rare but well described in the literature. A review of 24 severe cases showed that neurological symptoms occurred in 92%, cardiovascular symptoms in 54%, visual disturbances in 42%, digestive tract signs in 25% and renal failure in 21%. The mortality was 25%.

Fluid absorption causes a transient hyponatremia & hypervolaemia with an increase in central pressures, which plateaus within 15 min(39,40). Shortness of breath, uneasiness, chest pain and pulmonary oedema may develop on the operating table(39,41) particularly during operations associated with a small blood loss(42).

Factors promoting the haemodynamic changeover include natriuresis, osmotic diuresis intracellular uptake of water. Hyponatraemia, hypocalcaemia, low serum osmolality, acute lowering of the body temperature(45) and release of prostatic substances(43) or endotoxins(44) may also contribute. Therefore, bradycardia and a marked increase in systolic

arterial pressure down to 50–70 mm Hg at the end of, or just after, the operation is often the first sign suggesting TUR syndrome(27,46). Pulmonary oedema might also develop late, indicating that serum sodium is <100 Meq/ liter(47,48) in coexistence with severe hypo-osmolality(49).

Heart

Disturbances of cardiac function due to excess water and hyponatremia might be an important cause of cardiovascular collapse. Depression of the conductivity system, bradycardia, and depression of the ST segment and T wave is common also in humans with massive fluid absorption(27,47, 50,51).

Brain

Brain oedema is a serious problem and cerebral herniation developing a few hours postoperatively is a major cause of death from fluid absorption, in addition to cardiovascular or respiratory collapse(50,51).

Sterile water as Irrigant:

Sterile water is often used for cystoscopy as it offers the surgeon a very clear view of the operating field. Warnings against using sterile water for irrigation during electrosurgery are based on both animal experiments(65) and clinical experience; but, more recently, several authors have recommended the fluid for limited resections(63,64).

Although there is no agreement about how much sterile water is needed to cause renal failure, damage requiring chronic haemodialysis still occurs with accidental and unexpected absorption of sterile water(62). Sterile water could be expected to promote cerebral edema more vigorously than other electrolyte-free irrigating fluids.

Low Pressure Irrigation

Performing TURP with a low fluid pressure, below the critical pressure for intravascular

absorption, would limit the risk. This can be achieved by applying a suprapubic evacuation instrument (Reuter's trocar) or a special channel in a resectoscope (the Iglesias technique).

The variable effectiveness is probably because of outflow obstruction by blood clots, which raises the fluid pressure. Low-pressure irrigation is probably more efficient if combined with monitoring of the intravesical pressure.

MATERIALS AND METHODS

Area Selection:

The study was conducted among In-patients of Urology Department, Kilpauk Medical College hospital and Govt. Royapettah Hospital.

Period selection:

The study was conducted in between period from February 2005 to January 2007.

Patient Selection:

A total of 100 Benign Prostatic Hyperplasia with bothersome symptomatic / Acute Urinary Retention Patients who underwent Transurethral Resection of Prostate were selected.

The following are the patient's inclusion and exclusion criteria:

INCLUSION CRITERIA:

- **Benign Prostatic Hyperplasia with bothersome symptomatic / Acute Urinary Retention Patients, with or without medical co – morbid medical illness.**

EXCLUSION CRITERIA:

1. **Bladder Neck Hypertrophy**

2. **Carcinoma Of Bladder**
3. **Carcinoma Of Prostate**
4. **Benign hyperplasia of Prostate with Bladder Stones.**
5. **Benign Hyperplasia of Prostate with Carcinoma Bladder.**
6. **Recurrent Benign Hyperplasia of Prostate**
7. **Residual Benign hyperplasia of Prostate**
8. **Benign Prostatic Hyperplasia Patients Who Underwent TUR of Prostate and Died of other than TUR syndrome.**

A total of 100 bothersome Symptomatic Benign Prostatic Hyperplasia patients, those who underwent Transurethral Resection of Prostate in Urology Department, Kilpauk Medical College hospital and Govt. Royapettah Hospital were studied during this period., between the age groups of 48 – 95 yrs, the average age being 71.5 yrs.

All the above patients were evaluated for Benign Prostatic Hyperplasia. The following evaluations were done on these patients preoperatively:

- **Symptoms Assessment(IPSS- Score)**
- **Urine culture & sensitivity**
- **Heamogram**
- **Blood urea, sugar, Creatinine & Electrolytes**
- **Ultrasonogram of Kidney, Ureter, Bladder & Prostate with Post void Residual Urine volume.**
- **Uroflowmetry**
- **Office Urethrocystoscopy.**
- **Cardiac Evaluation**
- **Pulmonary Evaluation if needed.**

Constants in study

- **Spinal Anesthesia**
- **Sterile Water as irrigant**
- **Placing the irrigating fluid drum at 60 cm above the operating table.**
- **22 fr irrigant rubber tube.**

- **24 fr non continuous irrigation resectoscope sheath.**
- **Resection without SPC**
- **Done by equally skilled surgeons**

Variables observed in Study

- **Patient Age**
- **Co morbid Medical Illnesses**
- **Gland size**
- **Immediate Preoperative Serum sodium Value.**
- **Immediate preoperative Pulse Rate**
- **Immediate Preoperative blood pressure**
- **Resection Time**
- **Irrigant Volume**
- **Blood Pressure immediately Completing the procedure**
- **Pulse Rate immediately completing the procedure**

- **Immediate Post Operative Serum sodium Value**
- **Symptoms & Signs in PeriOperative Periods.**

Co morbid conditions:

Co morbid conditions associated with Transurethral Resection Patients are

1. **Hypertension**
2. **Diabetes Mellitus**
3. **Coronary Artery Disease.**
4. **Chronic Obstructive or Restrictive Pulmonary Diseases.**
5. **Chronic Renal Failure**

Gland Size Measurement:

Gland size is measured by conventional ultrasound. By ultrasound dimensions of prostate in the axial plane, transverse and anteroposterior dimensions are measured at the estimated point of widest transverse diameter. The measurements in centimeters applied to the following formula to calculate the volume of prostate in cubic centimeter

Gland Volume in cc =

$\pi \div 6 \times$ *transverse dimension* $\times$ *AP dimension* $\times$

longitudinal dimension

The volume in cubic centimeters of prostate is comparable to weight in grams due to its specific gravity, which is 1.050 (68).

Serum sodium Measurement:

Blood samples 5cc in amount collected immediate pre and post operative periods. Serum is separated from blood by centrifuging sample at 3000 RPM for 10 minutes. Serum sodium is measured in our hospital laboratory by *Flame Emission Spectrophotometry* **.**

Flame Emission Spectrophotometry:

Principle: **Serum is diluted in a diluent containing known amounts of lithium or cesium, and aspirated into a propane air flame. Sodium ,lithium and cesium ions, when excited emit spectra with sharp bright lines at 589,671 and 852 nm respectively. Light emitted from the thermally excited ions is directed through separate interference filters to corresponding photo detectors. The lithium or cesium ions emission signal is used as an internal standard against Na+ signals are compared. The system is calibrated relative to low and high concentrations of each analyte, and the relation of signal to concentration is defined by an associated microprocessor.**

Resection Time:

Resection time is the period in minutes between time of initiation of resection to the time at which last activation diathermy is done.

Irrigant Volume:

Irrigation volume is volume of Sterile Water in liters which is irrigated during the period of Resection time.

Symptoms and Signs in Perioperative period:

Clinical Signs and symptoms observed in perioperative period were categorized as mild , moderate and severe (Table – 2), (1,30,31,32)

MILD	MODERATE	SEVERE
Headache	Disoriented	BP Not Recordable
Retching	Confusion	Persistent Cyanosis
Restless	Apprehensive	Oliguria
Irritation	Breathlessness	Signs of Shock

Nausea	**Chest pain**	**Anuria**
Vomiting	**Twitchings**	**Coma**
Pricking Sensation	**Cyanosis**	
Tremor	**Semiconscious**	
Bradicardia 10 - 20 B/M	**Bradicardia >20 B/M**	
Hypertensive 10 - 20mm Hg	**Hypertensive 20 - 50 mm hg**	
Hypotensive 30 - 50 mm hg	**Hypotensive > 50 mm hg**	
	Visual Abnormality	

RESULTS

This study was conducted at Kilpauk Medical College Hospital and Government Royapettah Hospital on 100 Benign Prostatic Hyperplasia patients from February 2005 to January 2007. All the patients were underwent Transurethral Resection of Prostate.

Following observations are made in this study:

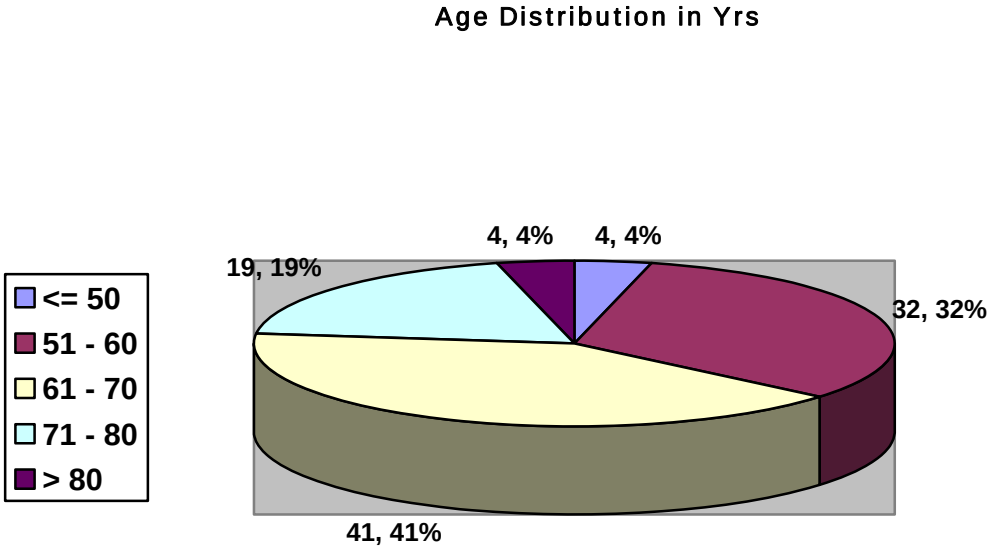
Age Distribution

Table 3

		No of Patients (N)	Percentage (%)
Age Group (Yrs)	<= 50	4	4
	51-60	32	32
	61-70	41	41
	71-80	19	19
	> 80	4	4

100 Patients in the age range of 48 – 95 yrs were observed; the average age being 71.5 yrs. observed patients were divided in to 5 age groups (Table 3).

In this study youngest patient observed was 48 years old, eldest patient observed was 95 years old. Majority of patients (41%) have come under 61 – 70 group. younger than 51 years were only 4 (4%) patients. Elder than 80 years were only 4 (4%) patients.



Serum Sodium changes (calculated from Immediate Pre and Post operative serum sodium value) and tabulated (Master Chart).

Degree of Sodium change among this various age group of patients analyzed statistically by ANOVA followed by Turkey HSD test.

TABLE 4

Descriptive
Na+ difference In relation with Age Group

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum *	Maximum *
					Lower Bound	Upper Bound		
<= 50	4	1.00[a]	2.944	1.472	-3.68	5.68	-2	4
51-60	32	4.25[ab]	3.312	.585	3.06	5.44	-1	11
61-70	41	4.56[ab]	1.817	.284	3.99	5.13	1	10
71-80	19	5.00[b]	3.197	.733	3.46	6.54	2	14
> 80	4	6.75[b]	2.630	1.315	2.57	10.93	3	9
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted sodium value more in post operative than pre operative sample.

* Values with Positive side denoted sodium value less in post operative than pre operative sample.

TABLE 5.

ANOVA Significance of Sodium Difference					
	Sum of Squares	df	Mean Square	F	P Value.
Between Groups	76.142	4	19.036	2.573	0.043*
Within Groups	702.848	95	7.398		
Total	778.990	99			

***** This P value denotes significant at 5% level

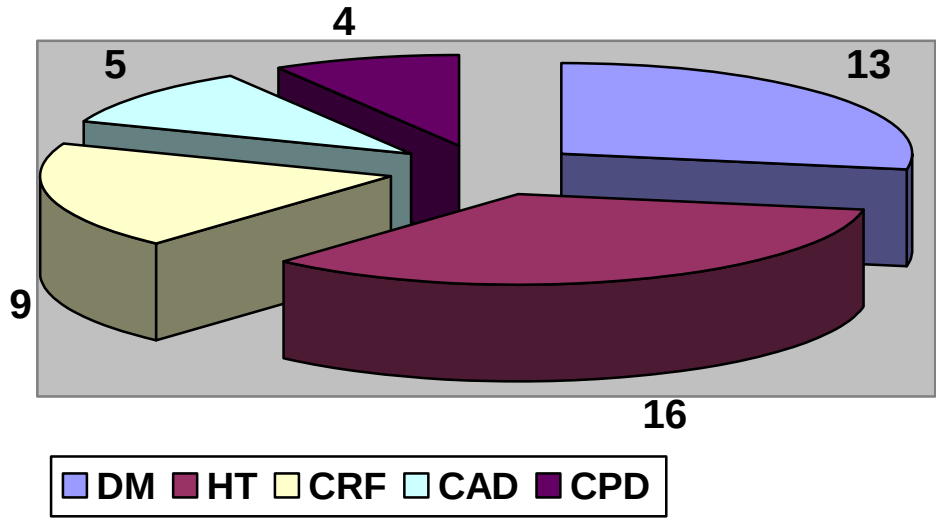
Sodium level has gone down to 14 Meq/L, gone up to 2 Meq/L post operatively. Major fluctuation in serum sodium(2 - 14 Meq/L) seen in 71 – 80 years age group patients. But Mean Sodium Decrease (6.75 Meq/L)was highest in > 80 years age group, and also Mean hyponatremia was more pronounced when Patient age was more. This observation was significant. P value was 0.043, which is statistically significant.

Co morbid conditions

TABLE 6.

Co morbid conditions	No. of Patients
Diabetes Mellitus	10
Hypertension	13
Coronary Artery Disease	6
Chronic Lung Disease	4
Chronic Renal Failure	8

Co morbid Medical Illness



Among 100 patients observed, 38 patients suffered from co morbid medical illness. 16 patients

were suffered from Hypertension. 13 patients suffered from Diabetes Mellitus, 9 Patients suffered from Chronic Renal Failure. 5 patients suffered from Coronary Arterial Disease, and 4 patients suffered from Chronic obstructive or restrictive Pulmonary Diseases. 3 patients suffered from both Diabetes and Hypertension.

Degree of Sodium change among this various age group of patients analyzed statistically by ANOVA followed by Turkey HSD test.

TABLE 7.

Descriptive

Sodium Difference in relation with Co morbid Conditions

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum *	Maximum *
					Lower Bound	Upper Bound		
Normal	62	4.42[a]	2.889	.367	3.69	5.15	-2	11
CAD	6	4.50[ab]	1.378	.563	3.05	5.95	2	6
CPD	4	4.25[bc]	.957	.479	2.73	5.77	3	5
CRF	8	7.63[c]	3.420	1.209	4.77	10.48	4	14
DM	7	2.43[d]	1.902	.719	.67	4.19	-1	4
DM/HT	3	3.33[de]	1.155	.667	.46	6.20	2	4
HT	10	4.30[e]	2.058	.651	2.83	5.77	2	8
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted , sodium value more in post operative than pre operative sample.

* Values with Positive side denoted, sodium value less in post operative than pre operative sample.

TABLE .8

ANOVA
Significance of Sodium Difference

	Sum of Squares	df	Mean Square	F	P Value
Between Groups	113.2873	6	18.8812	2.6377	0.0209 *
Within Groups	665.7027	93	7.1581		
Total	778.9900	99			

- This P value denotes significant at 5% level

Degree of Sodium changes in patients with co morbid medical illness compared with normal patients. Sodium value gone down to 14 Meq/L and gone up to 1 Meq/L, which is compared with normal patients. Sodium change was higher in patient with co morbid medical illness than the normal

patients. The P value is 0.0209 , which is statistically significant.

Patients with co morbid medical illness, Sodium Difference was compared with gland size, irrigant volume and resection time by finding correlation coefficients with P value.

- CRF patients

TABLE 9.

	Correlation Coefficients	P value	Significance
Gland Size	0.6729	0.012	Yes
Irrigant Volume	0.8541	0.007	Yes
Resection Time	0.8844	0.004	Yes

Patients with CRF, Sodium value gone down to 14 Meq/l. this much of hyponatremia was not seen in other groups. Minimal sodium decrease was 4 Meq/L. All Patients with CRF showed hyponatremia of 4 Meq/L at least.

Table .9, compares sodium difference in CRF patients with Gland size, Resection time and Irrigant

volume. Which shows all the three factors are statistically significant. So in CRF patients with larger Gland, Prolonged Resection time, and large Irrigant volume showed high degree of hyponatremia. Patients with CRF underwent resection in less than 40 minutes did not develop TUR Syndrome.

- CAD patients

TABLE . 10

	Correlation Coefficients	P value	Significance
Gland Size	0.7644	0.077	Not
Irrigant Volume	0.8226	0.044	Yes
Resection Time	0.7736	0.071	Not

Patients with CAD, Sodium value gone down to 6 Meq/l. All Patients with CAD showed hyponatremia of 2 Meq/L at least. Table .10, compares sodium difference in CAD patients with Gland size, Resection time and Irrigant volume. Which shows Irrigant volume was statistically significant. So in CAD patients with large Irrigant volume showed high degree of hyponatremia.

- CPD patients

Table .11

	Correlation Coefficients	P value	Significance
Gland Size	0.4264	0.574	Not
Irrigant Volume	- 0.1974	0.803	Not
Resection Time	- 0.2818	0.718	Not

Patients with CPD, Sodium value gone down in the range of 3 to 5 Meq/l. Table .11, compares sodium difference in CPD patients with Gland size, Resection time and Irrigant volume. Which shows all the three factors are statistically Insignificant.

- DM patients

TABLE .12

	Correlation Coefficients	P value	Significance
Gland Size	0.7422	0.056	Not
Irrigant Volume	0.4424	0.320	Yes
Resection Time	0.7085	0.075	Not

Patients with DM, Sodium value gone down to 4 Meq/l and gone up to 1 Meq/L.

Table .12, compares sodium difference in DM patients with Gland size, Resection time and Irrigant volume. Which shows Irrigant volume was statistically significant. So in DM patients with large Irrigant volume showed high degree of hyponatremia.

- HT patients

TABLE .13

	Correlation Coefficients	P value	Significance
Gland Size	0.7252	0.018	Yes
Irrigant Volume	0.5473	0.102	Not
Resection Time	0.7494	0.013	Yes

Patients with HT, Sodium value gone down in the range of 2 to 8 Meq/l.

Table .13, compares sodium difference in HT patients with Gland size, Resection time and Irrigant volume. Which shows Gland size and Resection Time were statistically

significant. So in HT patients with larger Gland, Prolonged Resection time showed high degree of hyponatremia.

- DM/HT patients

TABLE. 14

	Correlation Coefficients	P value	Significance
Gland Size	0.1555	0.0401	Yes
Irrigant Volume	0.2014	0.046	Yes
Resection Time	-0.10000	0.001	Yes

Patients with DM/HT, Sodium value gone down in the range of 2 to 4 Meq/l.

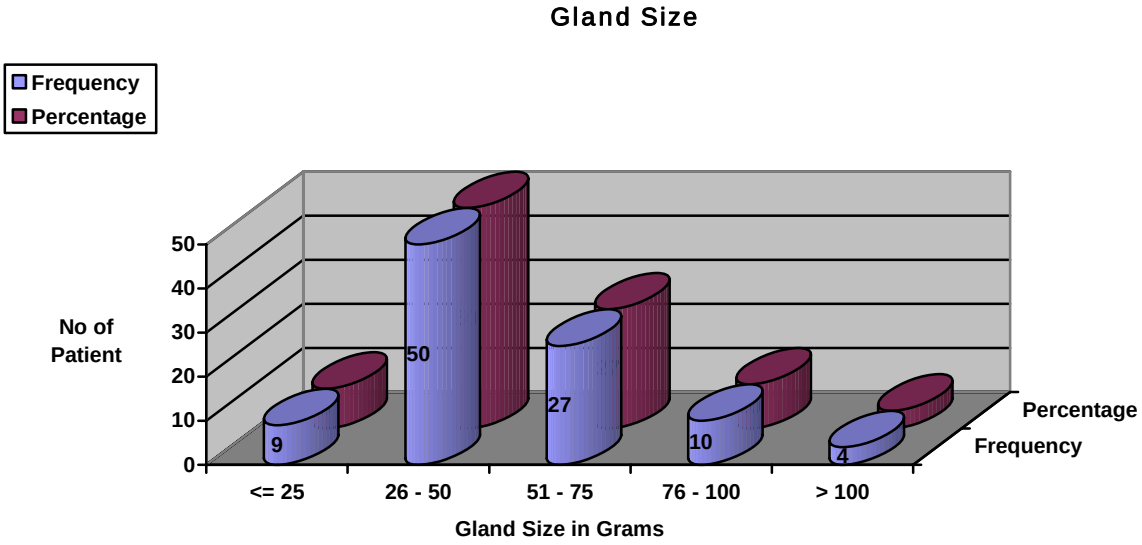
Table .14, compares sodium difference in DM/HT patients with Gland size, Resection time and Irrigant volume. Which shows Gland size and Resection Time and Irrigant Volume were statistically significant. So in HT patients with larger Gland, Prolonged Resection time and using larger irrigation fluid showed high degree of hyponatremia.

Gland Size

In this study largest gland resected was 108 Gms, smallest resected gland was 23 Gms in size. Majority of patients (50%) have come under 26 - 50 Gms group.

TABLE. 15

		No of Patients (N)	Percentage (%)
Gland Size In Gms.	<= 25	9	9
	26-50	50	50
	51-75	27	27
	76-100	10	10
	> 100	4	4



Degree of Sodium change among this various age group of patients analyzed statistically by ANOVA followed by Turkey HSD test.

TABLE .16

Descriptive

Sodium Difference in Relation With Gland Size

Gland size in Gms	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum *	Maximum *
					Lower Bound	Upper Bound		
<= 25	9	1.89[a]	1.833	.611	.48	3.30	-1	4
26-50	50	3.22[ab]	1.694	.240	2.74	3.70	-2	6
51-75	27	5.67[bc]	2.587	.498	4.64	6.69	2	14
76-100	10	8.00[cd]	1.826	.577	6.69	9.31	4	10
> 100	4	9.50[d]	1.291	.645	7.45	11.55	8	11
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted , sodium value more in post operative than pre operative sample.

* Values with Positive side denoted, sodium value less in post operative than pre operative sample.

TABLE .17

ANOVA
Significance of Sodium Difference

	Sum of Squares	df	Mean Square	F	P Value
Between Groups	402.521	4	100.630	25.394	0.001 *
Within Groups	376.469	95	3.963		
Total	778.990	99			

* This P value denotes significant at 1% level

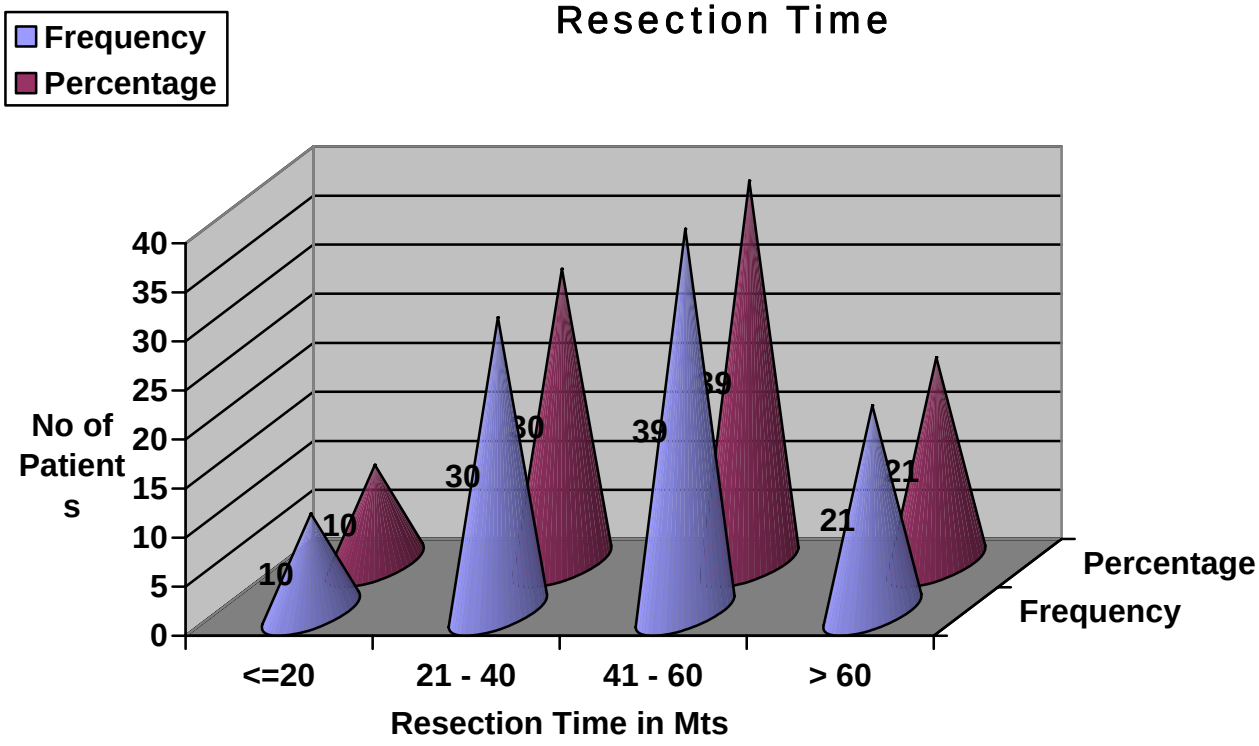
Sodium level has gone down to 14 Meq/L, gone up 2 Meq/L post operatively. Major fluctuation in serum sodium(2 - 14 Meq/L) seen in 51 – 75 Gms group patients. But Mean hyponatremia (9.50 Meq/L) was highest in > 100 Gms group, and also Mean hyponatremia was more pronounced when gland size was more. This observation was significant. P value was 0.001, which is statistically significant.

Resection Time

In this study Resection time observed in the range of 17 – 90 minutes. Majority of patients (39%) have come under 41 – 60 Minutes group.

TABLE .18

		No of Patients (N)	Percentage (%)
Resection Time in Mts	<= 20	10	10
	21-40	30	30
	41-60	39	39
	> 60	21	21
Total		100	100



Degree of Sodium change among this various age group of patients analyzed statistically by ANOVA followed by Turkey HSD test.

TABLE . 19

Descriptive

Sodium Difference in Relation with Resection Time

Resection Time in Mts	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
<= 20	10	2.20[a]	1.814	.573	.90	3.50	-1	4
21-40	30	3.43[a]	1.633	.298	2.82	4.04	-2	6
41-60	39	3.82[a]	2.138	.342	3.13	4.51	-1	11
> 60	21	8.33[b]	2.058	.449	7.40	9.27	5	14
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted , sodium value more in post operative than pre operative sample.

* Values with Positive side denoted, sodium value less in post operative than pre operative sample.

TABLE . 20

ANOVA
Significance of Sodium Difference

	Sum of Squares	df	Mean Square	F	P Value
Between Groups	413.613	3	137.871	36.225	0.001 *
Within Groups	365.377	96	3.806		
Total	778.990	99			

* This P value denotes significant at 1% level

Sodium level has gone down up to 14 Meq/L, gone up 2 Meq/L post operatively. Major fluctuation in serum sodium(5 - 14 Meq/L) seen in Resection Time more than 60 Mints group patients. Mean Sodium Decrease (8.33 Meq/L) was also highest in Resection Time more than 60 Mints group, and also Mean hyponatremia was more pronounced when Resection time was more. This observation was significant. P value was 0.001, which is statistically significant.

Irrigant Volume

In this study Irrigant volume observed was in the range of 10 – 32 Liters. Majority of patients (32%) have come under Irrigant volume 20 – 24 Liters group.

Table .21

		No of Patients (N)	Percentage (%)
Irrigant Volume in Ltrs	< 15	16	16
	15-19	28	28
	20-24	32	32
	25-29	18	18
	>= 30	6	6
Total		100	100

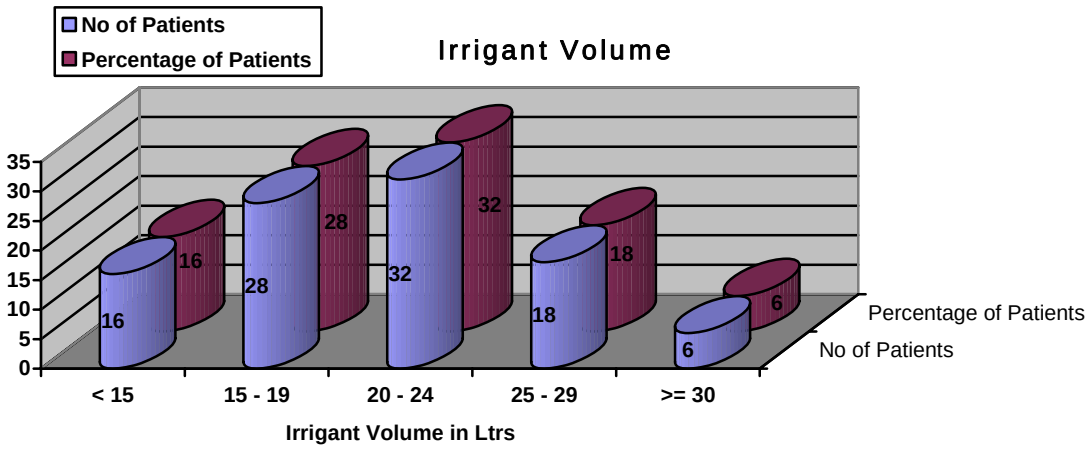


TABLE . 22 Descriptive

Sodium Difference in Relation with Irrigant Volume

Irrigant Volume In Ltrs	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		* Minimum	* Maximum
					Lower Bound	Upper Bound		
< 15	16	2.75[a]	1.571	.393	1.91	3.59	0	6
15-19	28	3.36[a]	2.112	.399	2.54	4.18	-2	7
20-24	32	4.22[a]	2.282	.403	3.40	5.04	-1	11
25-29	18	6.67[b]	2.910	.686	5.22	8.11	2	14
>= 30	6	9.33[c]	.816	.333	8.48	10.19	9	11
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

Degree of Sodium change among this various age group of patients analyzed statistically by Anova followed by Turkey HSD test.

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted , sodium value more in post operative than pre operative sample.

* Values with Positive side denoted, sodium value less in post operative than pre operative sample.

TABLE .23

ANOVA
Significance of Sodium Difference

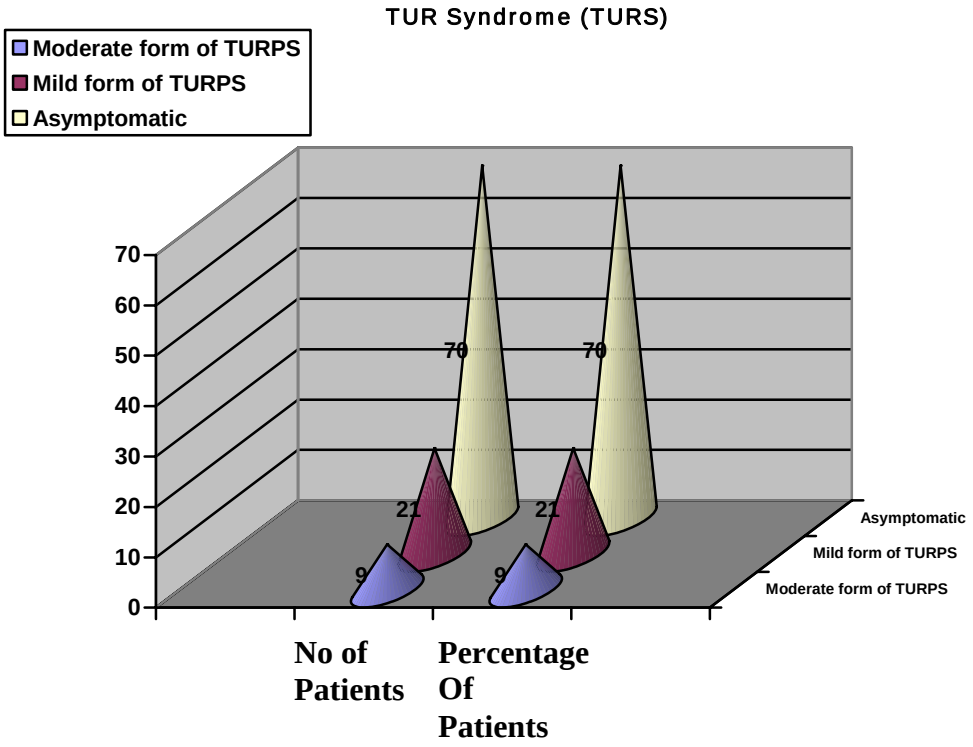
	Sum of Squares	df	Mean Square	F	P Value
Between Groups	312.759	4	78.190	15.932	0.001*
Within Groups	466.231	95	4.908		
Total	778.990	99			

* This P value denotes significant at 1% level

Sodium level has gone down up to 14 Meq/L, gone up 2 Meq/L post operatively. Major fluctuation in serum sodium(2 - 14 Meq/L) seen in 25 – 29 Liters Irrigant group patients. But Mean Sodium Decrease (9.33 Meq/L) was highest in Irrigant Volume more than 30 Liters group, and also Mean hyponatremia was more pronounced when Irrigant volume was more. This observation was significant. P value was 0.001, which is statistically significant.

Symptomatic Vs Asymptomatic Patients – **TABLE .24**

	No of Patients (N)	Percentage (%)
Asymptomatic	70	70
Mild Form TURS	21	21
Moderate Form TURS	9	9
Total	100	100



Degree of Sodium change among this various age group of patients analyzed statistically by ANOVA followed by Turkey HSD test.

TABLE . 25

Descriptive

Sodium Differences in relation with TURP Syndrome

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum *	Maximum *
					Lower Bound	Upper Bound		
Asymptomatic	70	3.27	1.760	.210	2.85	3.69	-2	8
Mild	21	6.52	2.400	.524	5.43	7.62	2	11
Moderate	9	9.22	2.682	.894	7.16	11.28	4	14
Total	100	4.49	2.805	.281	3.93	5.05	-2	14

- Different alphabet between age groups denotes significant risk at 5% level

* Values with negative symbol (-) denoted , sodium value more in post operative than pre operative sample.

* Values with Positive side denoted, sodium value less in post operative than pre operative sample.

TABLE .26

ANOVA
Significance of Sodium Difference

	Sum of Squares	df	Mean Square	F	P Value
Between Groups	392.3535	2	196.1767	49.2171	0.001*
Within Groups	386.6365	97	3.9859		
Total	778.9900	99			

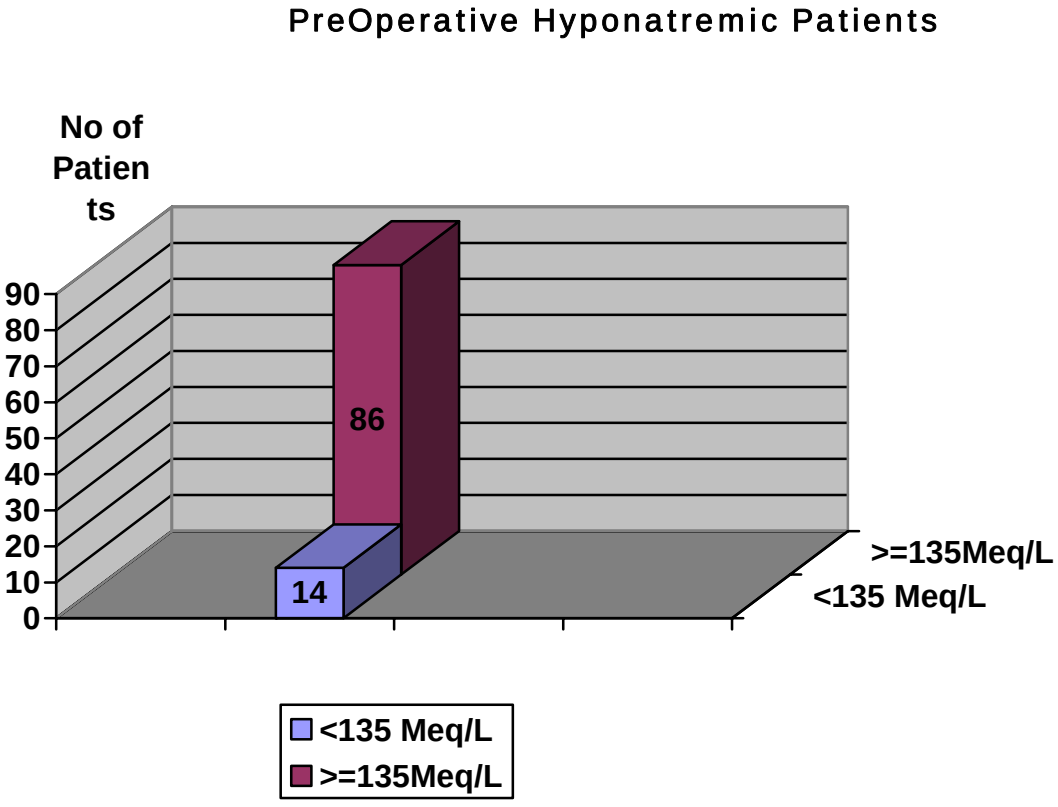
* This P value denotes significant at 1% level

Sodium level has gone down to 14 Meq/L, gone up 2 Meq/L post operatively. Major fluctuation in serum sodium(4 - 14 Meq/L) seen in Moderate TURP syndrome group patients. Mean Sodium Decrease (9.22 Meq/L) was also highest in Moderate TURP syndrome group. This observation was significant. P value was 0.001, which is statistically significant. In asymptomatic patients Mean sodium was 3.27 Meq/L, and Sodium level has gone down to 8 Meq/L, gone up to 2 Meq/L post operatively. Severe TURP syndrome was not observed in any patient.

Sodium Changes in Previously Hyponatremic Patients

TABLE .27

	Na+ (Meq/L)	No of Patients(N)	Percentage(%)
	<135	14	14
Total	>= 135	86	86
Total		100	100



Pre operatively Hyponatremic Patients observed in this study were 14(N).

Sodium Changes in Previously Hyponatremic Patients compared with sodium changes in Normonatremic Patients by T test

T-Test

Group Statistics

	Na+ (Meq/l)	N	Mean	Std. Deviation	Std. Error Mean
Na Difference	< 135	14	3.64	1.277	.341
	>= 135	86	4.63	2.963	.319

Levene's Test for Equality of Variances: F = 4.816, P = 0.031*

* This P value denotes significant at 5% level

T test shows that pre operative hyponatremic patients were developed statistically significant (P value = 0.031) changes in serum sodium.

Sodium Difference in Relation with BP & PR Changes

Blood pressure(SAP) compared with pre and post operative values, which gone up to 26mm of Hg, and gone down to 30 mm of Hg.

Pulse Rate (PR) compared with pre and post operative values, which gone up to 16 Bpm, and gone down to 12 Bpm.

Blood pressure change, Pulse rate change correlated with Serum Sodium change, by Paired Samples Statistics, Paired Samples Correlations and Paired Samples Correlations.

Paired Samples Correlations

		N	Correlation	P Value
Pair 1	**Na Difference & BP - Difference**	100	.406	0.001*
Pair 2	**Na Difference & PR - Difference**	100	-.429	0.001*

All the above tests showed degree of hyponatremia directly proportional to Blood pressure elevation P Value is 0.001, which is significant, inversely related with Pulse Rate, P value is 0.001, which is significant at 15% level.

Discussion

The results of the present study were analyzed and compared with other studies.

There is rapid accumulation of fluid in intravascular space occurs during Transurethral Resection of Prostate surgery, in this situation Effective Renal Function is very important factor to clear this excess load. Effective Renal Function is impaired in condition like Aged patients, Renal Failure patients. these patients are unable to distribute the excess fluid as rapidly as it is accumulated. This leads to “Dilutional Hyponatremia”, which is responsible for Transurethral Resection Syndrome.

Age and Sodium Dynamics:

In my study Age is a significant factor which affects sodium changes in TURP patients. This study shows, age is directly proportional to the degree of hyponatremia. Richard H. Harrison III et al has shown in his study

that age is a risk factor for development of TURP syndrome(1). .Bosch et al has shown in his study, in elderly patient Extra Cellular volume deficit slightly over a liter with Electrolyte deficit. Glomerular filtration rate and renal blood flow decrease by about 1% per annum after the age of 30 years in normal person. Renal excretion of water load decreases with age. Degree of Dilutional Hyponatremia more in elderly(1). Logan and Holtgrewe et al have concluded that There appears a profound increase in mortality and morbidity rate after the seventh decade of life.

Co Morbid Illness and Sodium Dynamics:

In my study Co Morbid Medical illness; Chronic Renal Failure, Coronary Arterial Diseases, Diabetes Mellitus and hypertension are significant factors which affects serum post operative serum sodium values.

Chronic Renal Failure:

Among this Chronic renal Failure is the Most Significant Co Morbid illness. In my Study Patients with Chronic Renal Failure did not develop TURP syndrome, if Gland size was < 40 Gms, Resection Time was < 40 Minutes, and Irrigant Volume was < 15 Liters. Holtgrewe H and Valk W et al have concluded Azotemia patients had TURP syndrome 1.7% than normal patients 0.7%(75). The Activity of healthy Kidney to eliminate intra operative Fluid load is thus a factor attaining statistical significance(75). The patients who display nitrogen retention on admission experience ill effects from a prolonged operative procedure (75).

Coronary Arterial Disease:

In patients with Coronary Arterial Disease Irrigant volume was a statistically significant factor in my study. In CAD Patients >=20 liters of irrigant fluid volume patient developed TURP syndrome. In Cardiac Patient fluid over load is the significant factor decides morbidity and mortality. Richard H.

Harrison III et al has shown in his study that cardiac disease patient is the candidate for the TURP syndrome, due to low salt diet, digitalis, diuretics, and reduced exercise.

Diabetes Mellitus :

In patients with Diabetes Mellitus, Irrigant volume was a statistically significant factor in my study. Richard H. Harrison III et al has shown in his study that Chronic Illness like Diabetes Mellitus have markedly reduced total body water, electrolytes and blood volume, they are more prone for the Transurethral Resection Reaction(1).

Hypertension:

In Patients with Hypertension, Gland size and Resection Time were significant factor in my study. Richard H. Harrison III et al has shown in his study that hypertension have markedly reduced total body water, electrolytes and blood volume, they are more prone for the Transurethral Resection Reaction(1).

Diabetes Mellitus and Hypertension :

In Patients with Diabetes mellitus and Hypertension, Gland size, Irrigant volume and Resection time were significant factor in my study. Richard H. Harrison III et al has shown in his study that Chronic Illness like Diabetes Mellitus and Hypertension have markedly reduced total body water, electrolytes and blood volume, they are more prone for the Transurethral Resection Reaction(1).

Gland Size and Sodium Dynamics:

In my Study Mean sodium decrease was increased when Gland size was increased. This observation was Statistically significant. When gland size increases, Resection time naturally increases. Chance of fluid absorption will be more. In my study patients did not develop TUR syndrome even with large glands (<=78gms),but all they had their resection time was within 60 minutes. AUA Cooperative study by Mebust et al 1989 has concluded that risk of TUR syndrome is more, if the gland is more than 45 Gms in size(76). Agius AM, Cutajar CL et al has

concluded that serum sodium change was high with large gland size.

Resection Time and Sodium Dynamics:

In my study Mean sodium decrease was increased when Resection was increased. This observation was significant. Mean Sodium Decrease (8.33 Meq/L) was also highest in Resection Time more than 60 Mints group. Major fluctuation in serum sodium(5 - 14 Meq/L) seen in Resection Time more than 60 Mints group patients. CRF patients were asymptomatic if resection time was restricted up to 40 minutes. Desmond J et al reported that dangerous fluid absorption during TURP is prevented by keeping the operating time below 60 Minutes(49). Nesbid reported that the Resection time should be limited to 60 Minutes(77,78). Richard H. Harrison III et al limited their resection time approximately to 60 minutes to prevent high degree of dilutional hyponatremia and TUR syndrome(1). Hagstorm, in his studies on fluid absorption, correlated resection

time with fluid absorption and found that from 10 – 30 cc of fluid are absorbed for each minute of resection time(79).

Irrigant Volume and Sodium Dynamics:

In my study Mean sodium decrease was increased when Irrigant volume was increased. This observation was significant. Significant amounts of fluid may be absorbed during a TURP, especially if venous sinuses are opened. Hahn RG, Ekengren J have concluded that major fluid absorption rarely stops once initiated and often coincides with a decrease in arterial pressure(8). Madsen and Naber(9) irrigation rate of 300 mL/min was necessary to maintain good visualization and that this rate cannot be adequately maintained if the fluid height is less than 60 cm. Due to poor visibility, if irrigation rate was increased by raising the height of the fluid from 60 cm to 70 cm doubled the irrigation fluid pressure. Madsen and Naber(9) found that fluid absorption was directly related to irrigation fluid pressure. If More fluid absorbed, more degree of dilutional hyponatremia.

TUR syndrome and Sodium Dynamics:

In my study Sodium level has gone down up to 14 Meq/L. Mean Sodium Decrease (9.22 Meq/L) was also highest in Moderate TURP syndrome group. This observation was significant. All patients with mild TUR syndrome had the serum sodium level <=130 Meq/l post operatively. All patients with Moderate TUR syndrome had the serum sodium level <=125 Meq/L post operatively. The clinician should be aware of a mild TUR syndrome, which is easily overlooked. This presents with nausea and often a sudden reduction in arterial pressure 30–45 min after the operation(30,31,32). Serum sodium is lowered 5–10 Meq/liter(14). Hyponatremia (<120 Meq/liter) may cause muscle weakness, muscular twitches, epileptic seizures and shock(10). In my study lowest post operative value of Sodium found was 122 Meq/liter ; that patient had moderate TUR syndrome.

In my study 21% had mild TUR syndrome which can be easily overlooked. Absorption of small amounts of fluid (1–2 liter) occurs in 5–10% of patients undergoing

transurethral prostatic resection and results in an easily overlooked mild transurethral resection (TUR) syndrome(81).

Preoperatively Hyponatremic patients and Sodium Dynamics:

In my study pre operative hyponatremic patients were developed statistically significant changes in serum sodium. Serum sodium gone down to 10 Meq/Liter. Mean decrease in serum sodium level was 5.5Meq/Litre. One patient with chronic pulmonary disease has come under moderate TUR syndrome group; since he had vomiting, confusion Headache, Breathlessness, increased blood pressure and decreased pulse rate. His breathlessness might have been due to pulmonary problem. But rest of the features put him in the moderate TUR syndrome group. Pre operatively he had hyponatremia ;128 Meq/Liter, post operative sodium level was 124 Meq/l. Difference is only 4 Meq/liter. Richard H. Harrison III et al has shown in his study that Aging, chronic illness, malnutrition, debilitation and emaciation are conditions associated with markedly reduced total body water, electrolytes, and blood volume. These

individuals have preoperative hyponatremia, they are more prone for TUR syndrome(1).

Sodium Dynamics in Relation with BP & PR Changes:

In my study degree of hyponatremia directly proportional to Blood pressure elevation, inversely related with Pulse Rate, both are proved significant by statistics. These finding correlates with intracranial pressure rise. N.S.R Maluf, J.S.Boren and G.E.Brandes has concluded in their study that intracranial pressure tended to rise during resection. The change averaged +79 mm of CSF, to the maximum of +198 mm of CSF, showed the greatest gain in weight and became hypertensive(80).

CONCLUSION

- In patients aged more than 80 years without co morbid medical condition, degree of post resection hyponatremia will be more. It is better to complete procedure as quick as possible with low volume irrigation.
- In Renal Deficiency Patients, degree of post resection hyponatremia will be more, in relation with Gland size, irrigant volume and resection time. It is safe to complete the procedure within 40 minutes or restrict irrigant volume 15 liters, which ever is earlier.
- In Coronary Artery Disease Patients, degree of post resection hyponatremia will be more, in relation with irrigant volume. It is safe to restrict irrigant Fluid volume less than 20 Liters.
- In patients with Diabetes and hypertension, degree of post resection hyponatremia will be more. It is better to complete procedure as quick as possible with low volume irrigation.

- Patients aged less than 80 years and without co morbid medical conditions, larger glands up to 78 Gms, may be safely resected, with the limit of 60 minutes resection time. Because, with these restriction of age group and resection time, degree of post resection hyponatremia will be less.
- Absorption of small amounts of fluid occurs in 21% of patients undergoing transurethral prostatic resection and results in an easily overlooked mild transurethral resection (TUR) syndrome. In this group of patients average degree of post resection hyponatremia will be around 5 Meq / Liter.
- In patients with Pre operatively hyonatremic, degree of post resection hyponatremia will be more. It is better to complete procedure as quick as possible with low volume irrigation.
- In perioperative blood pressure and pulse rate monitoring will help to pick up TUR Syndrome early.

MASTER CHART

S.N	Name	A	I.P No	IPSS Score	GS Gms	CoMd	RT	IRGT	(B.S) Na+	(A.S) Na+	~Na+	Symptoms / Signs Mild	Pre Op B.P	Post Op B.P	~B.P	Pre Op PR	Post Op PR	~PR	Asympt	Mild	Moderat	Severe
1	Sundaramoorthy	64	2295	19	42		55	26	138	133	5		130	126	-4	78	74	-4	+			
2	Poongavanam	80	2551	20	55	CRF	62	25	136	122	14	Confusion, Irritation, Breathlessness,Vomiting	110	136	26	88	78	-10			+	
3	Sankar	81	3160	16	86	HT	72	28	132	124	8	confusion, irritation	144	160	16	72	68	-4			+	
4	kaliyan	55	3791	19	48		55	20	135	133	2		110	112	2	84	88	4	+			
5	Kanniyapilli	75	3793	21	32	DM	47	21	142	138	4		114	110	-4	76	80	4	+			
6	Abdulvahab	60	4773	15	60	CRF	55	22	136	128	8	Headache,Nausea	116	124	8	76	72	-4		+		
7	Kanniyappan	75	5589	22	108		86	29	135	125	10	Nausea,vomiting,confusion,irritation	116	130	14	82	74	-8			+	
8	Balasubramanian	57	5195	19	38	DM/HT	52	21	138	136	2		130	126	-4	76	84	8	+			
9	chinnakannu	65	5792	25	42		56	26	140	137	3		124	130	6	74	88	14	+			
10	Pavadai	57	9410	21	58		65	27	135	128	7	nausea,restlessness	124	130	6	82	76	-6		+		
11	Velmurugan	74	809757	28	46	HT	55	19	144	140	4		146	130	-16	78	84	6	+			
12	Ameer	72	811535	16	34	DM	48	20	135	133	2		110	116	6	76	90	14	+			
13	Kechani	82	812205	18	56	CRF	48	17	131	124	7	Confusion	136	144	8	86	80	-6			+	
14	Abdulkareem	58	813790	20	44	CAD	60	19	134	130	4		126	120	-6	76	82	6	+			
15	Pitchaikannu	60	814014	25	62		58	22	130	126	4		110	100	-10	80	92	12	+			
16	Narayanan	63	813201	24	23		21	14	136	135	1		116	122	6	68	74	6	+			
17	Vanu	70	813893	18	40	DM	48	19	138	135	3		130	124	-6	88	84	-4	+			
18	Munusamy	55	814769	19	28		50	21	130	128	2	nausea, vomiting	118	120	2	86	84	-2		+		
19	Sathyaseelan	60	814781	22	52	CPD	55	20	139	134	5		130	118	-12	80	78	-2	+			
20	Ramaraj	65	815390	24	48		61	22	135	129	6	irritation	128	136	8	90	82	-8		+		
21	Venkatasamy	60	816623	20	44		57	26	135	132	3		122	118	-4	78	84	6	+			
22	Kalimuthu	60	815688	16	30		44	18	132	130	2	vomiting	112	120	8	72	68	-4		+		
23	Subramani	76	19285	17	28		41	17	135	132	3		128	120	-8	78	74	-4	+			
24	Govindasamy	70	19290	20	36	HT	45	21	131	128	3		146	128	-18	80	76	-4	+			
25	Chinnaiyah	60	20820	25	88		78	30	137	128	9	rigor,chills,vomiting,irritation	126	140	14	86	78	-8		+		
26	David	60	18104	18	48	CPD	55	21	129	126	3		130	110	-20	68	74	6	+			
27	Chinnaiyah	60	20826	30	106		82	32	135	124	11	Confusion, nausea, vomiting,irritation	110	132	22	88	78	-10			+	
28	Raman	60	20269	28	58	CRF	50	19	137	130	7	vomiting,weakness,	126	134	8	70	68	-2		+		
29	Bhugai	60	21746	21	24		20	12	141	140	1		128	110	-18	74	80	6	+			
30	Thangagani	64	21680	28	72		55	26	135	130	5	tremer	114	130	16	88	78	-10		+		
31	Venkatesan	73	26547	26	60	CAD	50	20	135	130	5	nausea	118	122	4	80	78	-2		+		
32	Natarajan	68	21428	17	38		46	18	135	131	4		110	106	-4	66	74	8	+			
33	Kulandaivelu	60	22879	19	26		41	20	134	131	3		114	120	6	78	74	-4	+			
34	Natarajan	68	21428	25	96		70	28	135	128	7	Headache	122	130	8	80	76	-4		+		
35	Muthusamy	60	23416	22	48	HT	55	23	135	132	3		142	126	-16	78	84	6	+			

MASTER CHART

36	Janakiraman	66	24688	28	86		70	24	136	126	10	Tremer, Restlessness,Irritation	126	146	20	84	72	-12		+		
37	Natesan	65	23302	19	30	CAD	20	12	135	133	2		110	116	6	82	76	-6	+			
38	Subramaniyan	70	24164	26	78		58	20	144	140	4		128	120	-8	78	88	10	+			
39	Elumalai	76	24681	19	32		42	17	144	141	3		126	118	-8	76	78	2	+			
40	Muthu	75	24344	21	40		55	21	142	138	4		116	120	4	88	84	-4	+			
41	Palayan	64	24175	27	62		58	25	142	138	4		130	124	-6	78	80	2	+			
42	Narayanan	65	24911	19	23		19	11	139	137	2		126	120	-6	68	74	6	+			
43	Patchai	60	25398	24	52		40	18	139	135	4		122	114	-8	76	82	6	+			
44	Munuswamy	66	25979	12	51	HT	35	15	140	137	3		136	128	-8	68	74	6	+			
45	Kathirvel	95	27908	16	40		30	13	145	142	3		120	126	6	78	82	4	+			
46	Rajagopal	60	816933	20	56	CPD	39	15	128	124	4	breathlessness, vomiting, confusion, headache.	130	136	6	84	78	-6			+	
47	Pitchaikannu	65	816945	16	24		17	10	140	136	4		110	108	-2	74	78	4	+			
48	Sundaram	60	828286	19	38		33	20	138	136	2		126	120	-6	84	90	6	+			
49	Elumalai	70	828878	21	38	CRF	35	13	136	130	6		126	130	4	68	80	12	+			
50	C.J.Mani	70	828999	25	52		40	22	143	138	5		130	118	-12	78	86	8	+			
51	Chidamparam	63	829375	21	30	DM/HT	40	20	139	135	4		140	134	-6	74	76	2	+			
52	Mari	60	829980	29	48		55	24	138	133	5		110	112	2	76	74	-2	+			
53	Chinnaraj	57	830395	24	36		38	16	145	145	0		114	116	2	82	76	-6	+			
54	Ponnurangam	54	832484	24	44		45	24	139	140	-1		122	128	6	88	82	-6	+			
55	Yalobhusshin	73	833124	19	52	HT	39	16	136	132	4		140	126	-14	80	74	-6	+			
56	Kanniappan	64	841255	20	40		35	15	139	135	4		112	110	-2	74	78	4	+			
57	Abdulrahumam	64	845769	19	32		32	16	140	136	4		122	118	-4	78	74	-4	+			
58	Bakkri	65	845791	17	25		18	13	138	134	4		130	128	-2	72	76	4	+			
59	Natarajan	65	846363	20	48		40	22	136	131	5		118	114	-4	80	74	-6	+			
60	Narayanasamy	75	846939	22	28	CRF	20	10	135	131	4		128	122	-6	78	82	4	+			
61	Venugopal	80	848102	26	54	CAD	39	16	135	130	5		130	126	-4	76	82	6	+			
62	Gunasekar	60	848127	14	40		35	14	139	136	3		118	120	2	82	88	6	+			
63	Basheer	70	856955	19	36	HT	39	21	134	130	4	vomiting	126	136	10	86	78	-8		+		
64	Venu	60	7981	22	52		40	20	139	135	4		120	116	-4	72	78	6	+			
65	Nallathambi	58	8262	25	104		90	30	131	122	9	retching,restlessness,confusion	124	136	12	88	82	-6			+	
66	Ramalingam	56	8253	21	23		18	11	137	137	0		130	126	-4	78	80	2	+			
67	Vadivelu	60	9061	18	35		45	19	135	136	-1		110	116	6	68	74	6	+			
68	Munuswamy	70	9547	21	52	CPD	40	18	139	134	5		118	124	6	80	78	-2	+			
69	Sundaramoorthy	48	23145	17	28		30	17	137	139	-2		110	116	6	76	88	12	+			
70	Vengaiah	73	23398	19	25		20	10	138	136	2		130	132	2	78	76	-2	+			
71	Lakshmaiah	48	24682	18	48		55	22	135	132	3		124	120	-4	84	88	4	+			
72	Venkatareddy	72	24894	27	94		82	30	132	123	9	Confusion,retching	114	130	16	88	80	-8			+	
###	Muthukaruppan	75	25439	25	73	HT	55	27	136	134	2		110	112	2	80	88	8	+			

MASTER CHART

74	Joseph	71	28273	16	28		25	13	140	137	3		136	128	-8	74	78	4	+			
75	Rathakrishnan	67	28382	14	42		55	24	135	130	5	vomiting	110	128	18	88	80	-8		+		
76	Sakthinarayan	70	28269	16	30	CRF	37	15	138	134	4		140	146	6	88	86	-2	+			
77	Adhikesevan	77	28866	18	24		19	12	138	134	4		112	118	6	78	76	-2	+			
78	Perumal	85	30032	25	62		70	28	137	128	9	head ache	110	122	12	74	70	-4		+		
79	Dasarathy	70	31815	27	101	HT	81	29	132	124	8	headache, retching, confusion	136	140	4	78	76	-2			+	
80	Sambandam	68	33104	18	44	CAD	65	19	135	130	5		124	120	-4	76	82	6	+			
81	Anwardeen	59	857826	22	80		67	29	136	127	9	Headache, twitching	146	160	14	90	82	-8		+		
82	Abdul Majid	78	858968	29	90		75	30	139	130	9	retching,vomiting,	130	142	12	82	78	-4		+		
83	Subramanian	60	858646	19	48		40	18	140	137	3		122	118	-4	78	82	4	+			
84	Kannan	62	858634	16	60		67	25	135	129	6		140	110	-30	76	92	16		+		
85	Govindasamy	68	858973	24	48	CAD	65	28	136	130	6		110	116	6	82	90	8	+			
86	Shanmugam	50	858117	19	25	DM	20	15	138	139	-1		130	124	-6	78	74	-4	+			
87	Ramasamy	70	858962	20	42		48	22	135	130	5		124	120	-4	82	88	6	+			
88	Balu	60	858963	21	54	CRF	58	22	140	129	11	pricking & burning sensation over face and neck	110	124	14	74	70	-4		+		
89	Kathirvelu	60	859521	24	60		76	29	140	132	8		116	110	-6	78	74	-4	+			
90	Perumal Pillai	65	860483	26	78		70	30	135	126	9	headache, vomiting	124	130	6	80	76	-4		+		
91	Adhinarayanan	70	860676	19	55		40	19	136	132	4		124	122	-2	78	76	-2	+			
92	Sheikhmohamed	70	860673	16	48		55	22	138	134	4		130	124	-6	72	80	8	+			
93	Perumal	65	860609	22	44	HT	39	19	142	138	4		120	118	-2	78	82	4	+			
94	Jayaraman	70	860897	24	52	DM	40	18	139	135	4		118	124	6	68	74	6	+			
95	Balasamy	65	861984	19	56		45	21	135	130	5	retching	124	128	4	88	82	-6		+		
96	Dharman	67	861986	24	40	DM	35	14	140	136	4		118	124	6	76	72	-4	+			
97	Subburayalu	48	862883	17	52	DM/HT	40	16	135	131	4		130	128	-2	78	84	6	+			
98	Alagan	65	860149	16	76		65	25	135	129	6	nausea	110	116	6	88	82	-6		+		
99	kalyanasundaram	64	861396	21	30	DM	32	12	139	138	1		122	118	-4	90	84	-6	+			
100	Panjalai	80	859534	14	38		39	22	138	134	4		126	120	-6	78	86	8	+			

BIBLIOGRAPHY

1. Harrison, R.H., In II , Boren, J.S and Robison J.R. : Dilutional Hyponatremic shock: Another concept of the transurethral prostatic resection reaction . J. Urol., 75: 95, 1956.
2. George Berg, E.J. Fedor and Bernard Fisher: Physiological Observations Related to the Transurethral Resection Reaction. J. Urol. Vol. 87 , No. 4 . 1962.
3. Edelman I.S, Leibman J 1959 Anatomy of body water and Electrolytes. American J. of Medicine 27: 256, 257.
4. W.Aveling, C.Hamilton – Davis, Fluid, electrolytes and acid-base balance, RCS course manual. 3rd edition.
5. Lippmann. B.J.; Fluid and electrolytes management, Manual of Medical Therapeutics, 28th ed. G.A Ewald, C.R Mckenzie, Eds, New York, little brown & co, 1995.
6. Jonathan W. Heusel et al; Physiology and disorders of water, Electrolytes, and acid base metabolism., Tietz N.W ‘s principles of Biochemistry.
7. Hahn RG. Intravesical pressure during fluid absorption in TURP Scand J Urol Nephrol 2000; 34:102–8 .

8. Hahn RG, Ekengren J. Patterns of irrigating fluid absorption during transurethral resection of the prostate as indicated by ethanol. J Urol 1993; 149: 502–6.

9. Madsen PO, Naber KG. The importance of the pressure in the prostatic fossa and absorption of irrigating fluid during transurethral resection of the prostate. J Urol 1973; 109: 446–52

10. Ghanem AN, Ward JP. Osmotic and metabolic sequelae of Volumetric overload in relation to the TUR syndrome. Br J Urol 1990; 66: 71–8

11. Hahn RG. Ethanol monitoring of irrigating fluid absorption in transurethral prostatic surgery. Anesthesiology 1988; 68: 867–73

12. Jordan C.D. flood J.G. et al, case records massachusettes GH, Normal reference lab value, N.Engl. J. Med. 327:718 – 724, 1992.

13. Tietz N.W.Ed. Clinical guide to lab tests. 3rd edition. Philedelphia W.B sounders, 1995.

14. Hahn RG. Early detection of the TUR syndrome by marking the irrigating fluid with 1% ethanol. Acta Anaesthesiol Scand 1989; 33: 146–51

15. Physiology of solute transport, current opin. Nephrol. 5: 153 – 166, 1996.
16. Chui PT, Short T, Leung AKL, Tan PE, Oh TE. Systemic Absorption of glycine irrigation solution during endometrial ablation by transcervical endometrial resection. Med J Aust 1992;
17. Siddiqui MA, Berns JS, Baime MJ. Glycine irrigant absorption syndrome following cystoscopy. Clin Nephrol 1996; 45: 365–6.
18. Ichai C, Cialis JF, Roussel LJ, et al. Intravascular absorption of glycine irrigating solution during shoulder arthroscopy: a case report and follow-up study. Anesthesiology 1996; 85: 1481–5
19. Dimberg M, Norle´n H, Ho¨ glund N, Allge´n L-G. Absorption of irrigating fluid during percutaneous transrenal lithotripsy. Scand J Urol Nephrol 1993; 27: 463–7.
20. Hyponatremia pathophysiology, fluids and electrolytes, Harrisson Principles of internal medicine, 13th edition.
21. Hahn RG. Transurethral resection syndrome after transurethral resection of bladder tumours. Can J Anaesth 1995; 42: 69–72.
22. Hahn RG. Smoking increases the risk of large-scale fluid

absorption during transurethral prostatic resection. J Urol 2001; 166:162–5.

23. Salmela L, Aromaa U, Lehtonen L, Peura P, Olkkola KT. The effect of prostatic capsule perforation on the absorption of irrigating fluid during transurethral resection. Br J Urol 1993; 72: 599–60

24. Richard H. Harrison III, et al, ; Dilutional hyponatremic shock: Another concept of TURP reaction, J. Urol, 1956, 75: 95 – 105

25. Sohn MH, Vogt C, Heinen G, Erkens M, Nordmeyer N, Jakse G. Fluid absorption and circulating endotoxins during transurethral resection of the prostate. Br J Urol 1993; 72: 605–10

26. Weis N, Jo¨ rgensen PE, Bruun E. ‘‘TUR syndrome’’ after Transurethral resection of the prostate using suprapubic drainage. Int Urol Nephrol 1987; 19: 165–9

27. Baba T, Shibata Y, Ogata K, et al. Isotonic hyponatremia and cerebrospinal fluid sodium during and after transurethral resection of the prostate. J Anesth 1995; 9: 135–41

28. Balzarro M, Ficarra V, Bartoloni A, Tallarigo C, Malossini G. The pathophysiology, diagnosis and therapy of the transurethral resection of the prostate syndrome. Urol Int 2001; 66: 121–6

29. Peters KR, Muir J, Wingard DW. Intraocular pressure after transurethral prostatic surgery. Anesthesiology 1981; 55: 327–9

30. Hahn RG, Sandfeldt L, Nyman CR. Double-blind randomized study of symptoms associated with absorption of glycine 1.5% or mannitol 3% during transurethral resection of the prostate. J Urol 1998; 160: 397–401

31. Hahn RG, Shemais H, Esse´n P. Glycine 1.0% versus glycine 1.5% as irrigating fluid during transurethral resection of the prostate. Br J Urol 1997; 79: 394–400

32. Olsson J, Nilsson A, Hahn RG. Symptoms of the transurethral resection syndrome using glycine as the irrigant. J Urol 1995; 154: 123–8

33. Pe´rier C, Mahul P, Molliex S, Auboyer C, Frey J. Progressive changes in plasma and cerebrospinal fluid after transurethral prostatic resection. Clin Chem 1990; 26: 2152–3.

34. Hahn RG. Transurethral resection syndrome from extravascular absorption of irrigating fluid. Scand J Urol Nephrol 1993; 27: 387

35. Rothenberg DM, Berns AS, Ivankovich AD. Isotonic hyponatremia following transurethral prostate resection. J Clin Anesth 1990; 2: 48–53

36. Henderson DJ, Middleton RG. Coma from hyponatraemia Following transurethral resection of the prostate. Urology 1980; XV:267–71

37. Windsor A, French GWG, Sear JW, Foe¨x P, Millett SV, Howell SJ. Silent myocardial ischaemia in patients undergoing transurethral prostatectomy. Anaesthesia 1996; 51: 728–32

38. Andrew RD: Seizure and acute osmotic change: clinical and neurophysiological aspects. Journal of the Neurological Sciences, 101 (1991) 7-18.

39. Hahn RG. Hallucination and visual disturbances during transurethral prostatic resection. Intensive Care Med 1988; 14: 668–71

40. Hahn RG. Ethanol monitoring of irrigating fluid absorption (review). Eur J Anaesthesiol 1996; 13: 102–15

41. Drinker HR, Shields T, Grayhack JT, Laughlin L. Simulated Transurethral resection in the dog: early signs and optimal treatment. J Urol 1963; 89: 595–602

42. Hahn RG. Fluid and electrolyte dynamics during development of the TURP syndrome. Br J Urol 1990; 66: 79–84

43. Verilli RA, Uhlman RC, Viek NF, Hunsicker WC. The Hypotensive effect of a prostatic extract. J Urol 1962; 87: 184–6

44. Sohn MH, Vogt C, Heinen G, Erkens M, Nordmeyer N, Jakse G. Fluid absorption and circulating endotoxins during transurethral resection of the prostate. Br J Urol 1993; 72: 605–1

45. Evans JWH, Singer M, Coppinger SWV, Macartney N, Walker JM,Milroy EJG. Cardiovascular performance and core temperature during transurethral prostatectomy. J Urol 1994; 152: 2025–9

46. Singer M, Patel M, Webb A, Bullen C. Management of the transurethral prostate resection syndrome: time for reappraisal? Crit Care Med 1990; 18: 1479–80

47. Rothenberg DM, Berns AS, Ivankovich AD. Isotonic hyponatremia following transurethral prostate resection. J Clin Anesth 1990;2: 48–53

48. Butt AD, Wright IG, Elk RJ. Hypo-osmolar intravascular volume overload during anaesthesia for transurethral prostatectomy. A report of 2 cases. S Afr Med J 1985; 67: 1059–61

49. Desmond J. Serum osmolality and plasma electrolytes in patients who develop dilutional hyponatremia during transurethral

resection. Can J Surg 1970; 13: 116–21

50. Norris HT, Aasheim GM, Sherrard DJ, Tremann JA. Symptomatology, pathophysiology and treatment of the transurethral resection of the prostate syndrome. Br J Urol 1973; 45:420–7

51. Osborn DE, Rao PN, Greene MJ, Barnard RJ. Fluid absorption during transurethral resection. Br Med J 1980; 281: 1549–50

52. Baillo AM, Gassol JM, Redorta JP, Castro MN, Gime´nez NM. Physiopathology and surgical treatment of extravasated peritoneal fluid after transurethral resection. Eur Urol 1984; 10: 183–6

53. Olsson J, Hahn RG. Simulated intraperitoneal absorption of irrigating fluid. Acta Obstet Gynecol Scand 1995; 74: 707–13.

54. Mantha S, Rao SM, Singh AK, Mohandas S, Prakash Rao BS, Joshi N. Visual evoked potentials and visual acuity after transurethral resection of the prostate. Anaesthesia 1991; 46: 491–3

55. Wang JM-L, Creel DJ, Wong KC. Transurethral resection of the prostate, serum glycine levels, and ocular evoked potentials. Anesthesiology 1989; 70: 36–41

56. Hoekstra PT, Kahnoski R, McCamish MA, Bergen W, Heetderks DR. Transurethral prostatic resection syndrome—a new perspective: encephalopathy with associated hyperammonaemia. J Urol 1983; 130: 704–7

57. Hahn R, Andersson T, Sikk M. Eye symptoms, visual evoked potentials and EEG during intravenous infusion of glycine. Acta Anaesthesiol Scand 1995; 39: 214

58. Horgan KJ, Ottaviano YL, Watson AJ. Acute renal failure due to mannitol intoxication. Am J Nephrol 1989; 9: 106–9

59. Woods HF, Albert KGMM. Dangers of intravenous fructose. Lancet 1972; 2: 1354

60. Williams EL, Hildebrand KL, McCormick SA, Bedel MJ. The Effect of intravenous lactated Ringer's solution versus 0.9% sodium chloride solution on serum osmolality in human volunteers. Anesth Analg 1999; 88: 999–1003

61. Grove JJ, Shinaman RC, Drover DR. Noncardiogenic pulmonary edema and venous air embolus as complications of operative hysteroscopy. J Clin Anesth 2004; 16: 48–50

62. Dorotta I, Basali A, Ritchey M, O'Hara JF, Sprung J. Transurethral resection syndrome after bladder perforation. Anesth Analg 2003; 97: 1536–8

63. Grundy PL, Budd DWG, England R. A randomized controlled trial evaluating the risk of sterile water as an irrigating fluid during transurethral electrovaporization of the prostate. Br J Urol 1997; 890: 894–7

64. Memon A, Buchholz N-P, Salahuddin S. Water as an irrigant in transurethral resection of the prostate: a cost-effective alternative. Arch Ital Urol Androl 1999; LXXI: 131–4

65. Wakim KG. The pathophysiologic basis for the clinical manifestations and complications of transurethral prostatic resection. J Urol 1971; 106: 719–28

66. Creevy CD, Reiser MP. The importance of hemolysis in transurethral prostatic resection: severe and fatal reactions associated with the use of distilled water. *J Urol* 1963;89: 900–5.

67. Mommsen S, Genster HG, Moller J. Changes in the serum concentration of sodium, potassium, and free haemoglobin during transurethral resection of the prostate: parts of the TURP syndrome? *Urol Res* 1997;5:201–5.

68. Watanabe H, Igari D, Tanahashi Y, et al: Measurements of size and weight of prostate by means of transrectal ultrasonotomography. Tohoku J Exp Med 1974;114:277–285.

69. Hahn RG, Stalberg HP, Gustafsson SA. Intravenous infusion of irrigating fluids containing glycine or mannitol with and without ethanol. J Urol 1989; 142: 1102–5

70. Inman RD, Hussain Z, Elves AWS, Hallworth MJ, Jones PW, Coppinger SWV. A comparison of 1.5% glycine and 2.7% sorbitol–0.5% mannitol irrigants during transurethral prostate resection. J Urol 2001; 166: 2216–20

71. Hahn R, Berlin T, Lewenhaupt A. Irrigating fluid absorption and blood loss during transurethral resection of the prostate studied by a regular interval monitoring (RIM) method. Scand J Urol Nephrol 1988; 22: 23–30

72. Coppinger SWV, Lewis CA, Milroy EJG. A method of measuring fluid balance during transurethral resection of the prostate. Br J Urol 1995; 76: 66–72

73. Hubert J, Cormier L, Gerbaud PF, Guillemin F, Pertek JP, Mangin P. Computer-controlled monitoring of bladder pressure in the prevention of 'TUR syndrome': a randomized study of 53 cases. Br J Urol 1996; 78: 228–33

74. Heidler H. Frequency and causes of fluid absorption: a comparison of three techniques for resection of the prostate under continuous pressure monitoring. Br J Urol 1999; 83: 619–22

75. Holtgrewe H, Valk W: Factors influencing the mortality and

morbidity of transurethral prostatectomy: A study of 2,015 cases. J Urol 1962; 87: 450-9.

76. Mebust WK, Holtgrewe HL, Cockett AT, Peters PC: Transurethral prostatectomy: immediate and postoperative complications. A cooperative study of 13 participating institutions evaluating 3,885 patients. J Urol 1989 Feb; 141(2): 243-7

77. Nesbit R: Transurethral Prostatectomy. Springfield, Ill: Charles C. Thomas Publisher 1943.

78. Nesbit R: A history of transurethral prostatectomy. Rev Mex Urol 1975; 35: 349-62.

79. Hagstrom RS: Studies on fluid absorption during TURP. J. urol 1955:73:852-859

80. N.S.R.Maluf, J.S.Boren and G.E.Brandes et al, J. Urol, vol 75,No.5

May 1956.

81. R. G. Hahn*B. J. A 96 (1): 8–20 (2006)